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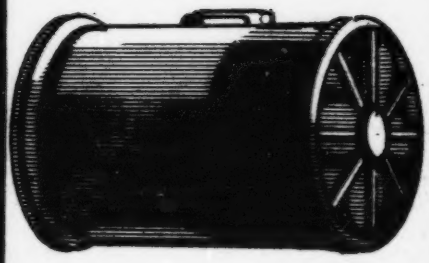
The economics of natural air grain drying



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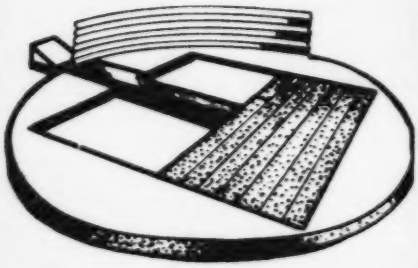

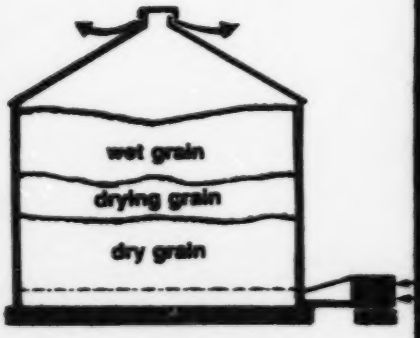

THE ECONOMICS OF NATURAL AIR DRYING

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1. Definition of Natural Air Grain Drying

The terms Natural Air Grain Drying and Aeration are sometimes interchanged, but there is a difference. Aeration is the blowing of low volumes of air through grain, sometimes as low as one-tenth cfm/bu*. The low volumes of air cools the grain, prevents moisture migration, and reduces mold growth and insect infestations. Aeration provides very little drying. Natural Air Drying accomplishes everything tht Aeration does but uses much higher air flow rates, in excess of one-half or one cfm/bu. The higher air flow rate speeds up the drying process but also costs more in terms of investment and operating costs.

2. Why Use Natural Air Grain Drying?

(a) Natural air drying has two advantages over hot air drying

- Low operating cost. It generally costs one to two cents per bushel for electricity to run a natural air drying fan providing an air flow of one-half to one cfm/bu;

- Natural air drying requires less labour than operating a hot air dryer.

(b) The following are advantages of drying grain regardless of the method

- Reduced grain damage results from combining tough rather than dry grain. PAMI Report #R180, January, 1981, compared a standard combine to a Stueckle modified combine in tough and dry Neepawa. The standard combine had 4.5% lower losses in tough Neepawa than dry Neepawa;

- Increased combine usage results from the addition of a drying system. Drying allows combining to start several days earlier each year. A drying system allows more hours of combining each day when damp evenings and rains result in increased kernel moisture. A dryng system may take the place of a second combine.

* Cubic feet per minute per bushel.

- Reduced grade losses result from advancing the date of combining. Grade losses are caused by adverse weather conditions, and the possibility of a loss in grade becomes greater the longer the crop remains in the field;

- Retaining kernel moisture can increase grain income. Each percent of moisture removed from wheat at $4.50/bu results in an average loss in value of 5 1/4¢/bu. If you start combining when the wheat moisture content is 14.5% then the moisture content of the last wheat to be harvested may be 10.5% on a dry year. By advancing the date of harvest the amount of overdry grain is reduced. The first wheat harvested can either be dried to 14.5% or held in condition to be mixed later with overdry wheat.

(c) The Disadvantages of Natural Air Drying Are:

- Extended drying time;

- All grain may not be dry in the fall;

- Bins containing tough grain must be monitored until the grain is dry;

- It is difficult to sample large bins;

- When drying a bin of grain to average dry the grain should be moved to mix the tough and overdry grain.

3. Management Factors and Other Equipment Needed

- Install Natural Air Drying equipment in large diameter bins for the lowest annual drying cost. When purchasing new bins the large diameter, higher capacity bins will also have the lowest annual storage cost per bushel when considering the bin and cement floor;

- Install a fan in each drying bin. Plan to start combining early to take advantage of higher temperatures in early fall that result in lower relative humidity and faster drying;

- Purchasing a grain moisture meter and grain sample probe will assist you in managing your natural air drying system. The moisture level of the grain going into the bin should be monitored to ensure that it doesn't exceed what the system was designed for. The drying process should be monitored to ensure that on average, the grain in the bin is not overdry.

1. Optimum Size of Existing Bins for Natural Air Drying

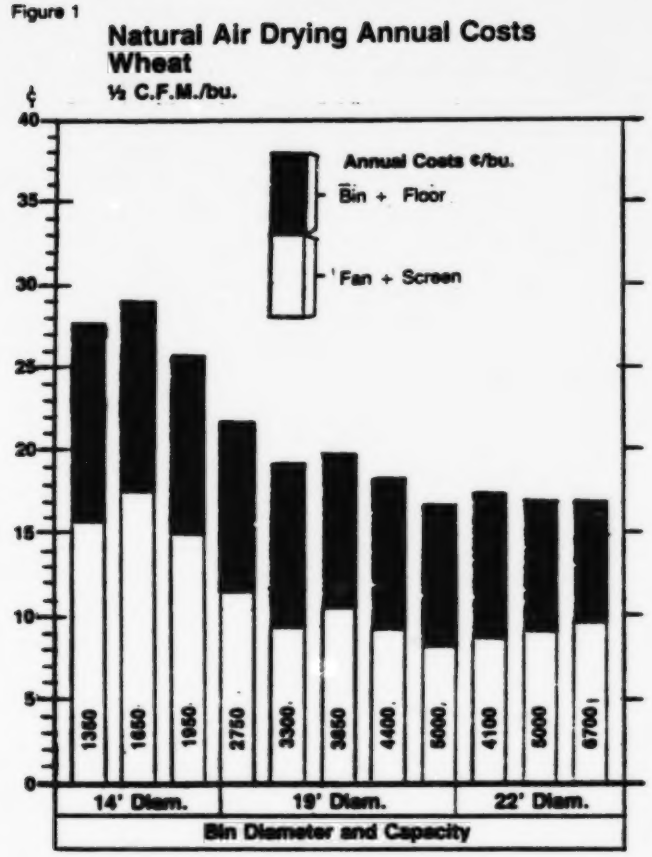
The annual costs of natural air drying were calculated in eleven different bin sizes:

14 foot diameter - 1350, 1650 and 12950 bushels
19 foot diameter - 2750, 3300, 3850, 4400 and 5000 bushels
22 foot diameter - 4100, 5000, and 6700 bushels

Example: Calculating the annual cost of fan + screen per bushel--5000 bu. bin, 19 foot diameter, wheat,1/2 cfm, fan + screen cost $2069.

Depreciation	$\frac{2069 - 206.90}{15 \text{ years}}$	=	$124.14
Investment	$\frac{2069 + 206.90}{2} \times .12$	=	136.55
Insurance	2069 x .01	=	20.69
Repairs	2069 x .03	=	62.70
Power			
5hp $\times \frac{750}{1000}$ watts	=3.75kw x $.0318 x 500 hrs	=	59.63
ANNUAL COST			$403.71
			8.1¢/bu

Figure 1



The same method was used to calculate the annual cost of fan and screen for eleven bin sizes. In Figure 1 the clear area below the shaded area indicates the annual cost of the fan and screen per bushel. The 19 ft. diameter, 5000 bu. bin has the lowest cost. Generally, the cost per bushel in the 19 ft. and 22 ft. diameter bins are less than the 14 ft. diameter bins.

2. Optimum Size if Purchasing a New Steel Bin, Installing a Cement Floor and Natural Air Drying Equipment.

   (a) The total annual costs of fan, screen, bin and cement floor is a figure we can use to compare different bin sizes. The annual cost of the fan and screen is already calculated. The following example shows the calculation of the annual cost of bin and floor for a 5000 bu. bin, 19 ft. diameter, the cost of the bin and floor is $3807.00.

Depreciation	$\frac{3807 - 380.70}{30 \text{ years}}$	= $ 114.21
Investment	$\frac{3807 + 380.70}{2} \times .12$	= 251.26
Insurance	3807 x .01	= 38.07
Repairs	3807 x .008	= 30.46
		$434.00
		8.7¢/bu

Total Annual Cost per Bushel - 5000 bu. bin 19' diameter wheat 1/2 cfm/bu.

Bin + cement floor	8.7¢/bu
Fan + screen	8.1¢/bu
	16.8¢/bu

This procedure was used in calculating the costs for each size of bin. In Figure 1 the clear area of each bar represents the annual cost of the fan + screen, the shaded area of each bar represents the annual cost of the bin + cement floor. The total height of each bar represents the total annual cost of the bin, cement, fan and screen. The large diameter bins have generally lower annual costs than the smaller diameter bins.

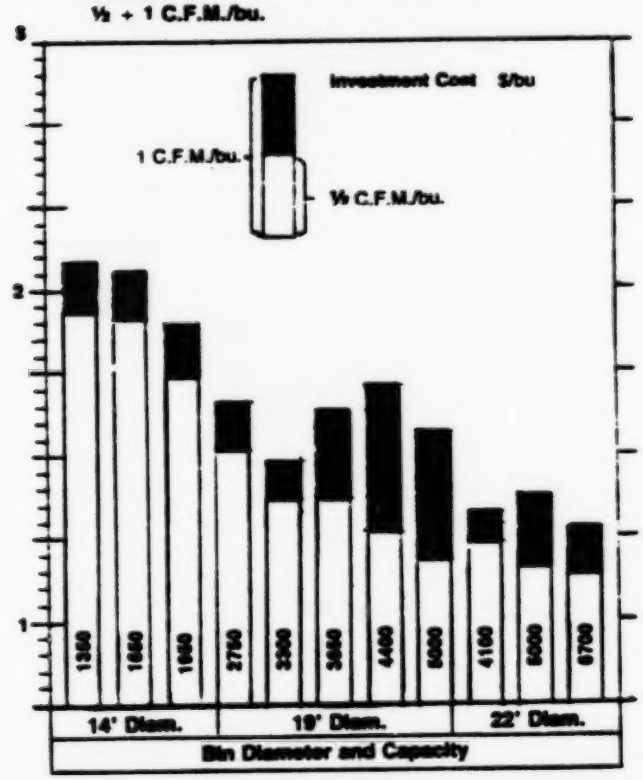
(b) Investment cost per bushel of different bin sizes is compared in Figure 2. The total purchase price of the bin, cement floor, fan and screen was added together and divided by the number of bushels.

Example: 5000 bu. bin, 19 ft. diameter, wheat 1/2 cfm/bu

	Original Cost
Fan	$1,320
Partial flush floor screen (11' x 11')	749
Bin	3,175
Cement Floor	632
TOTAL INVESMENT COST	$5,876
INVESTMENT COST/BU ÷ 5000 bu.	$1.18/bu

Figure 2

Natural Air Drying Investment Costs
Wheat
½ + 1 C.F.M./bu.



In Figure 2 the total height of the bars indicate the investment cost per bushel of the bin, floor, fan and screen at 1 cfm/bu. air flow. The clear area of each bar represents the investment cost per bushel of the bin, floor, fan and screen at 1/2 cfm/bu. air flow.

It is not always possible to size the fan exactly for a specified air flow because of gaps in fan sizes (i.e. 1 1/2 hp-3 hp-5 hp). When sizing the fan for a minimum of 1/2 cfm/bu. air flow in some cases the air flow exceeded the 1/2 cfm/bu. rate. To size the same bin for 1 cfm/bu. air flow then required less additional investment. In some cases sizing the fan for a minimum of 1 cfm/bu. air flow resulted in an air flow in excess of 1 cfm/bu.

3. Management of the Natural Air Drying System

(a) Methods of Managing a Natural Air Drying System

i) Let the fan run until the wheat at the top of the bin is 14.5%. This method results in an average moisture content that is dryer than 14.5% As the air is blown into the bottom of the bin it tends to over dry the grain at the bottom. By the time the top grain is 14.5% the bottom grain may be 10.5% and the average may be 12.5% Figure 6 will indicate the resulting loss in value from drying wheat to 12.5%. Overdrying will be determined by the relative humidity, and the air flow rate. Over drying may not be a problem every year but bins should be monitored closely in a fall that is extremely hot and dry.

ii) Shut off the fan when the average wheat moisture is 14.5%. Knowing the correct time to shut off the fan requires that the operator monitor the progress of the drying front as it moves through the bin. This means that you have to climb up on the bin and using a sample probe, take samples from different levels of the bin. When the grain is average dry it should be mixed either by transferring it to another bin or by taking several loads of the bin and dumping them back into the bin;

iii) If the grain is not average dry in the fall start the fan in below zero temperatures to freeze any damp grain in the bin, monitor the bin until you are able to dry it in the spring.

(b) Other Equipment Required

When filling your bins it is important that you monitor the grain moisture level to ensure that it does not exceed the moisture level your system is designed for. Only by monitoring the movement of the drying front can you determine when the bin is close to average dry. The following equipment will be extremely useful in managing a drying system:

Grain Moisture Meter	-	$ 825.00
Grain Sample Probe	-	180.00
Grain Temperature Probe	-	260.00
		$1265.00

4. Compare the cost to the net advantages of natural air drying. Consider only the fan and screen costs, assuming the bin and floor costs are allocated to the storage of grain.

Advantages of Drying Grain

(a) Natural Air Drying requires less labour than hot air drying;

(b) Reduced grain damage if combining when grain is tough.

(i) Effects of Moisture Content on Threshing

Figure 3

Moisture	Grain Damage % of Total
12%	2%
16%	1%
18%	1.5%
20%	.5%

Source -H.P. Harrison, 1975, Park Wheat

(ii) Reduced Combine Losses When Threshing Tough Neepawa Wheat. PAMI report #R180, January 1981 was comparing a standard combine to a Stueckle modified combine. The results showed reduced combine losses in tough Neepawa wheat as compared to dry Neepawa wheat when the combine is in good condition and well-adjusted. The losses from the standard combine are itemized in Figure 4.

Figure 4

Reduced Combine Losses When Threshing Tough Neepawa Wheat

(Standard Combine Losses in bu/hr)

Type of Loss	Dry Neepawa Wheat	Tough Neepawa Wheat
Walker	1 bu/hr	1 bu/hr
Shoe	3	1
Unthreshed Grain	2	2
Cracked Grain	17	7 bu/hr
TOTAL	23 bu/hr	11 bu/hr

Total Loss as a % of Threshed Grain:

$\frac{23 \text{ bu/hr}}{277 \text{ bu/hr}} \times 100 = 8.3\%$ $\quad\quad$ $\frac{11 \text{ bu/hr}}{289 \text{ bu/hr}} \times 100 = 3.8\%$

Shoe Loss as a % of Threshed Grain:

$\frac{3 \text{ bu/hr}}{277} \times 100 = 1.08\%$ $\quad\quad$ $\frac{1 \text{ bu/hr}}{289} \times 100 = .35\%$

Cracked Wheat as a % of Threshed Grain:

$\frac{17 \text{ bu/hr}}{277} \times 100 = 6.14\%$ $\quad\quad$ $\frac{7 \text{ bu/hr}}{289} \times 100 = 2.42\%$

Combining Neepawa tough rather than dry with a standard combine resulted in a reduced loss of 8.3% - 3.8% = 4.5%.

Harrison calculated reduced grain damage of 1.5% when combining wheat at 20% rather than 12% moisture. Harrison appears to be more in line with the actual grain damage on farms than the difference of 6.14% - 2.4% = 3.7% that occurred in the PAMI test. In the PAMI test, other than cracked grain, the only other difference between combining tough and dry was the shoe loss. Combining Neepawa tough resulted in a reduced loss of 1.08% - .35% = .73%. The advantage of combining at high moisture rather than dry is 1.5% reduced cracking plus .7% reduced shoe loss = 2.2%. Reduced losses of 2.2%.on a 30 bushel wheat crop at $4.50 per bushel wheat crop at $4.50 per bushel would increase income by $2.97/acre.

(c) Increased Combine Usuage
By combining at higher moisture levels, and drying, the combine can be operated more days per year and more hours per day.

(d) Reduced Grade Losses -

Grade loses are caused by adverse weather conditions and the possibility of a loss in grade occurring becomes greater, the longer the crop remains in the field. Combining at high grain moisture and drying will advance the date of combining over combining at low grain moisture levels. Advancing the date of combining reduces the chance of grade losses.

The following table shows the value that is lost when #1 wheat drops to #2, or when #2 wheat drops to #3:

Figure 5

AVERAGE SPREAD BETWEEN GRADES OF SPRING WHEAT
(Dollars Per Bushel)

Grades Spread	81-82	80-81	79-80	78-79	Average 4 Years
1CW and 1CW 13.5 - 2CW	$ .19	$ .25	$ .24	$ .24	$ .23
2CW-3CW	.25	.24	.23	.04	.19

(e) Retaining Kernel Moisture -

Wheat at 14.5% moisture is purchased by grain companies for the same price as wheat at 10.5% moisture. 14.5% moisture wheat weighs more than 10.5% moisture wheat so it is beneficial to sell your grain at the highest allowable moisture. By combining at high moisture and drying to 14.5% moisture you can ensure that your grain is not over dry. You may want to combine some grain tough; cool it, and mix it later with over dry grain. For example, a bin of 16.5% moisture wheat could be mixed with a bin of 12.5% moisture wheat to yield an average moisture of 14.5%. Your elevator agent may want you to haul the bins in separately so he can mix the two in the elevator to ensure proper mixing.

Drying wheat at $4.50/bu. from 14.5% to 13.5% results in the following loss in value:

At 14.5% in one bushel there is:

Water 60 lbs. x .145 = 8.7 lbs.
Dry Matter 60 lbs. - 8.7 = 51.3 lbs.

After drying to 13.5% moisture that bushel weighs:

$$\frac{\text{lbs. dry matter in 14.5\% wheat}}{\text{\% dry matter in 13.5\% wheat}} = \frac{51.3 \text{ lbs.}}{.865} = 59.31 \text{ lbs.}$$

.. loss in weight is 60 lbs.- 59.31 lbs. = .69 lbs.
The loss in value is $\frac{.69 \times \$4.50/\text{bu.}}{60 \text{ lbs.}}$ = 5.18¢/bu.

The above method was used to calculate the following table:

Figure 6

CHANGE IN WHEAT VALUE BY DRYING

Moisture %	Drying One Percent Each Percent	Cumulative Above + Below Dry	Change in Value 3300 bu. Wheat
18.5)	5.48¢/bu	+21.46¢/bu	$ +708
17.5)	5.4	+15.98	+527
16.5)	5.33	+ 10.58	+349
15.5)	5.25	+ 5.25	+173
14.5)	5.18	- 5.18	-171
13.5)	5.18	-10.36	-342
12.5)	5.1	-15.46	-510
11.5)	5.03	-20.49	-676
10.5			
Average	5.25¢/bu.		

If combining is not started until the grain is dry, several days of hot dry weather can reduce the grain moisture content far below dry. The following example illustrates the economic loss resulting from over drying.

Example: 7 quarter farm, 1050 acres cultivated
700 acres wheat x 26 bu/ac = 18,200 bu.

Average Grain Moisture	Loss in Value
13.5%	$ 943
12.5	1886
11.5	2814
10.5	3729

Disadvantages of Natural Air Drying

(a) Natural Air Drying has an extended drying period;
(b) You may not be able to dry the grain in the fall with natural air drying;
(c) Bins must be checked until the grain is dry; and
(d) Difficult to sample the center of the large bins.

PARTIAL BUDGET

Combining Wheat Tough and Drying with Natural Air

Added Costs		Added Returns	
Natural Air Drying Costs		Retaining Kernel Moisture -	
1 cfm/bu, 3300 bu. bin, wheat. Cost of 5 hp fan + screen = $2069		retain moisture at 14.5% rather than 12.5% savings of 10.36¢/bu (Figure 6).	
Depreciation $\frac{2069 - 206.90}{15}$	= 124.14	3300 bu x 10.36¢/bu	=$341.88
Investment $\frac{2069+206.90}{2}$ x .12	= 136.55	Reduced combine loss of 2.2% when combining tough	
Insurance 2069 x .01	= 20.69	wheat (Figure 3 + 4).	
Repairs 2069 x .03	= 62.07	Added grain combining 3300 bu -	
Power 3.75 Kw x $.0318 x 250 hrs.	= 29.81	3300 bu x.022 x $4.50	=$326.70
Annual Cost of Drying	$373.26		
Moving Grain When Average Dry		Reduced Grade Loss from advancing the date of combining	
2 augers x 3.3 hr x $9.07/hr	= $59.86		
Labour 4 hours x $9.00/hr	= $36.00		
TOTAL	$ 95.86		
Total Disadvantages	$469.12	Total Advantages	$668.58

The net advantage is $199.46 plus any reduced grade loss by advancing the date of harvest.

CONCLUSIONS:

Large diameter bins are the least expensive to equip with Natural Air Drying per bushel and the least expensive when considering annual costs. Consider each bin on an individual basis and install natural air drying equipment in more bins as long as the net benefits exceed the annual drying costs. Natural Air Drying may enable you to sell more grain at the maximum allowable moisture thereby increasing your income.

ASSUMPTIONS:

- Bin Life - 30 years
- Natural Air Drying System Life - 15 years
- Annual Fan Use - 1/2 cfm/bu. air flow - 500 hours
  - 1 cfm/bu. air flow - 250 hours
- A Fan in each Drying Bin
- Repairs - bin - .8% of original cost per year
  - air drying equipment - 3% of original cost per year
- Electricity - 3.18¢/Kwh (small farm rate)
  - power already in yard
- Insurance + Housing - 1% of original cost
- Interest Rate - 12% opportunity cost
- Cement Floor - 14' diameter bin - 4.3 cu. yds.x$80 =$344
  - 19' diameter bin - 7.9 cu. yds.x 80 = 632
  - 22' diameter bin -10.6 cu. yds.x 80 = 848
- Fan Prices

1.5 hp	18"	$ 714	5 hp cent.	$1400
3 hp	18"	925	7 hp cent.	2400
3 hp	24"	1100	10 hp cent.	2800
5 hp	24"	1320	15 hp cent.	3300
			20 hp cent.	3700

- Flush Floor Screen Prices

Size	Cost
8'x 8'	$ 443
11'x11'	749
13'x13'	1050